



Jet Propulsion Laboratory
California Institute of Technology

NASA's Multi-Angle Imager for Aerosols: Addressing the Health Impacts of Particulate Air Pollution

Abigail Nastan, John Haynes, Michael Garay, Olga Kalashnikova, Yang Liu, Jeff Walter, Dave Diner and the MAIA Team

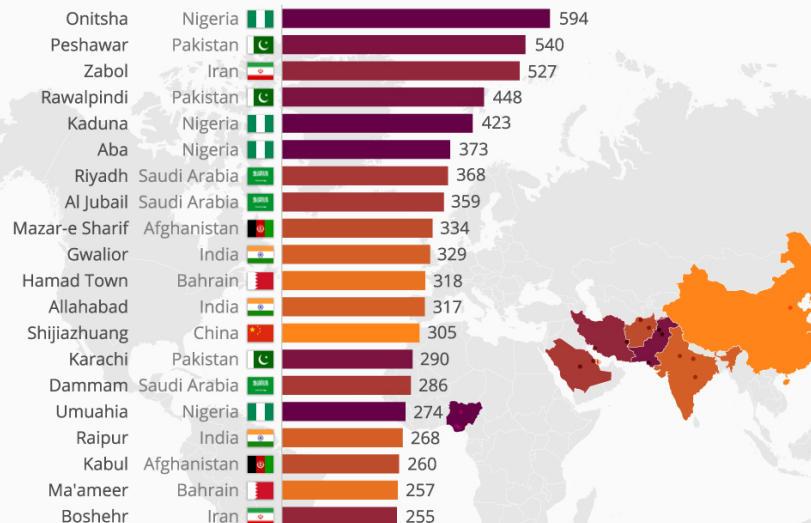
American Meteorological Society, January 8, 2018

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90% of the world's population lives in areas exceeding WHO's air quality guidelines

The 20 Worst Cities Worldwide For Air Pollution

Annual mean micrograms per cubic metre of PM10 in cities worldwide



© StatistaCharts Source: WHO

statista

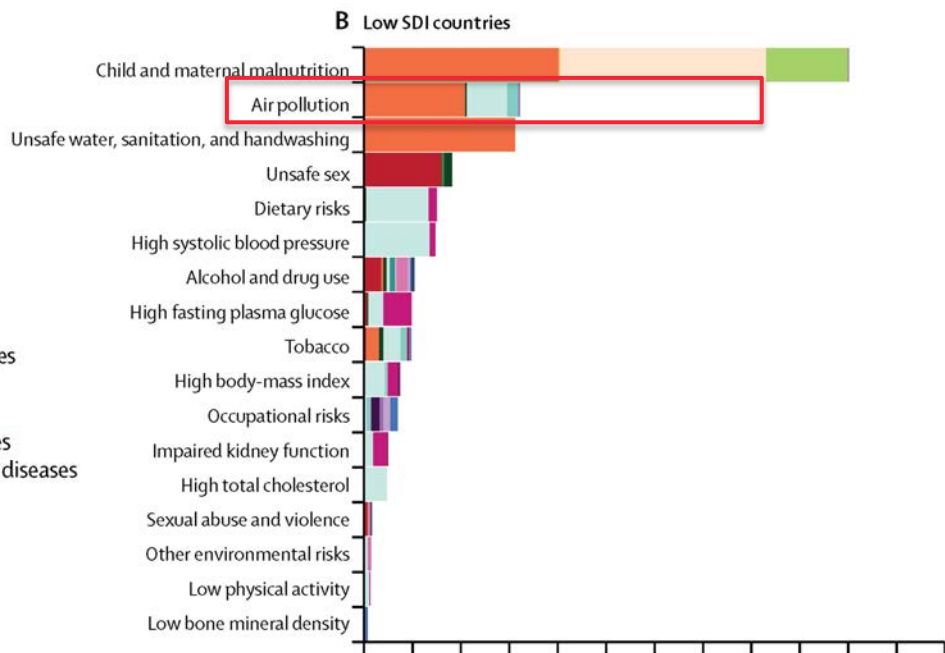
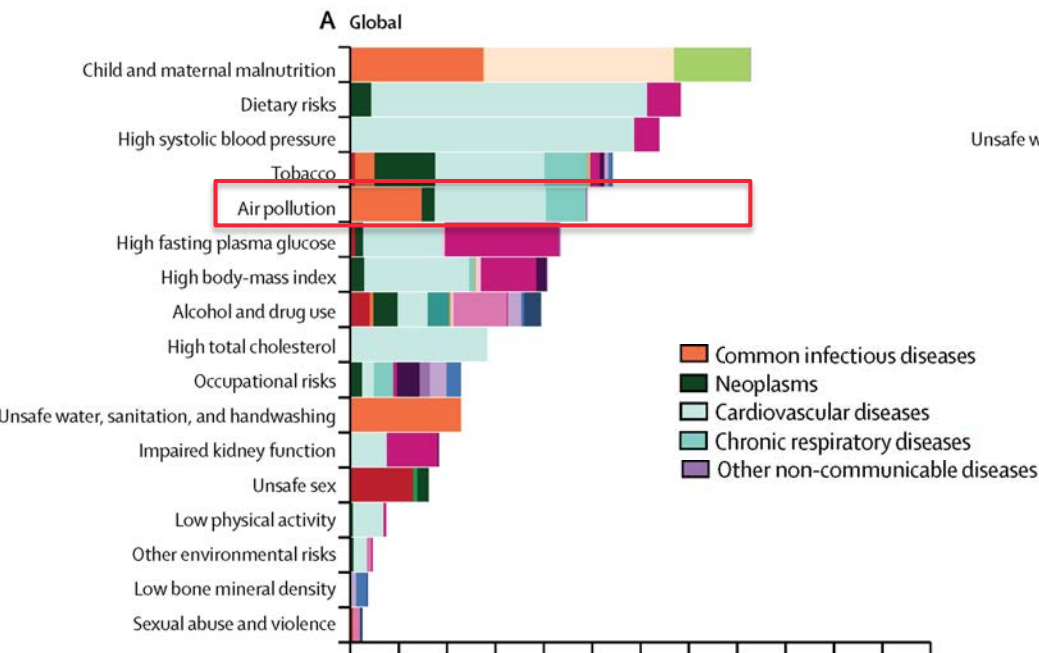
Niall McCarthy



Bobak, CC BY-SA 2.5



Particulate matter (PM) air pollution is the **top** global environmental risk factor for disease:



Global Burden of Disease 2016 Risk Factor Collaborators, 2017

Open question: Which **mixtures** of PM constituents are most harmful to humans?



Sulfate, nitrate, BC, OC



BC, OC

NOMAD, CC BY 2.0



Nitrate

Aqua Mechanical, CC BY 2.0



BC, OC, nitrate



Dust

Leaflet, CC BY-SA 3.0

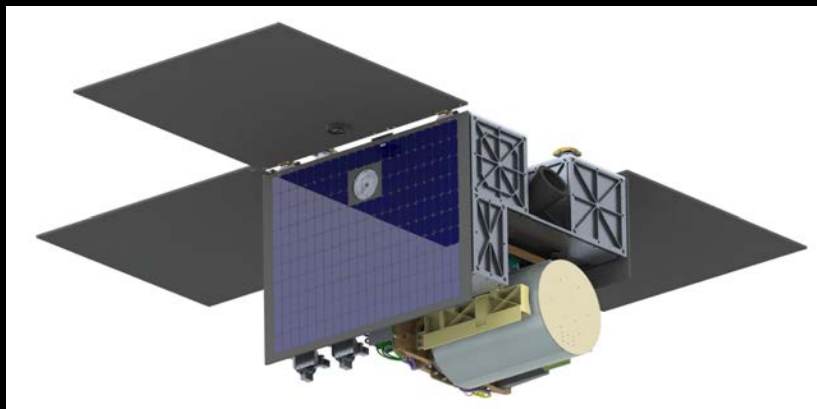
AMS Town Hall



Sulfate

Multi-Angle Imager for Aerosols (MAIA)

MAIA was selected in 2016, with launch in 2022 (to be confirmed) and a baseline mission of 3 years.



General Atomics

MAIA's science objective is to study the effects of various **types** of PM on:

- ✓ Acute illness and premature death
- ✓ Adverse birth outcomes
- ✓ Chronic disease

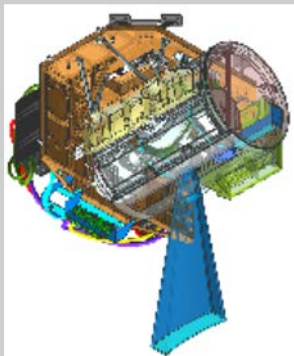
MAIA health studies are planned on PM types for ≥ 10 **Primary Target Areas (PTAs)**

The PTA candidates have been chosen based on:

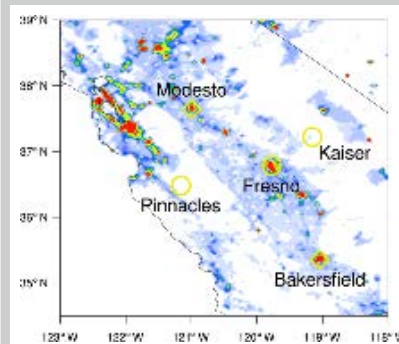
- ✓ Population
- ✓ PM characteristics
- ✓ Surface monitor data
- ✓ Health data
- ✓ Remote sensing considerations



The MAIA investigation concept



L. Tsutsui, KVPR



MAIA instrument

- Calibrated, georectified image data for retrieval of column-integrated AOD, fractional AOD, particle size.

Surface PM monitors

- Used to calibrate the aerosol-PM relationships.
- MAIA will use existing PM networks and deploy additional speciation monitors.

WRF-Chem

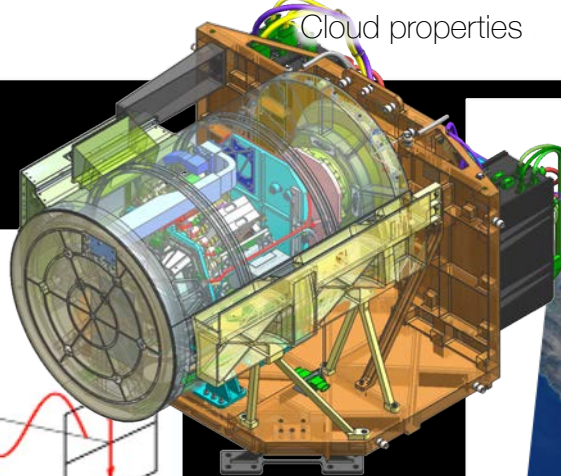
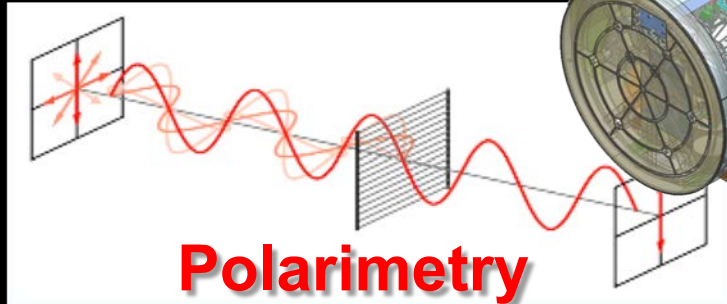
- Constrains aerosol vertical distribution.
- Assists spatial/temporal gap-filling.

Health records

- Obtained from Vital Statistics, hospitals, HMOs, administrative records, cohorts.
- Used to associate PM exposure with health effects.

The MAIA satellite instrument approach combines several remote sensing technologies:

Multispectral imaging



MAIA's Science Team combines data creators, data users, air quality and public health specialists

Principal Investigator	
David Diner	JPL

Co-Investigators: Instrument Characterization	
Carol Bruegge	JPL
Russell Chipman	Univ. of Arizona
Veljko Jovanovic	JPL

Co-Investigators: Aerosol Remote Sensing, Modeling, Validation	
Larry Di Girolamo	University of Illinois
Michael Garay	JPL
Edward Hyer	Naval Research Lab.
Olga Kalashnikova	JPL
Alexei Lyapustin	GSFC
Randall Martin	Dalhousie University
Jun Wang	University of Iowa
Feng Xu	JPL

Co-Investigators: PM Exposure, Epidemiology	
Michael Brauer	Univ. of British Columbia
Michael Jerrett	UCLA
Yang Liu	Emory University
Bart Ostro	UC Davis
Beate Ritz	UCLA
Joel Schwartz	Harvard University

Collaborators: Air Quality and Public Health	
Sagnik Dey	IIT Delhi
Sina Hashimenassab	SCAQMD
Kembra Howdeshell	NIH
John Langstaff	EPA
Pius Lee	NOAA
Fuyuen Yip	CDC

Applications activities

MAIA Applications Plan

Because MAIA is an **applications-focused mission**, applications efforts capitalize on science team connections and pre-established user community of epidemiologists

Applications Plan and Traceability Matrix

- ✓ Establish MAIA and ASP agreement on applications activities
- ✓ Logical decomposition of how tasks will be undertaken

Community Contacts List

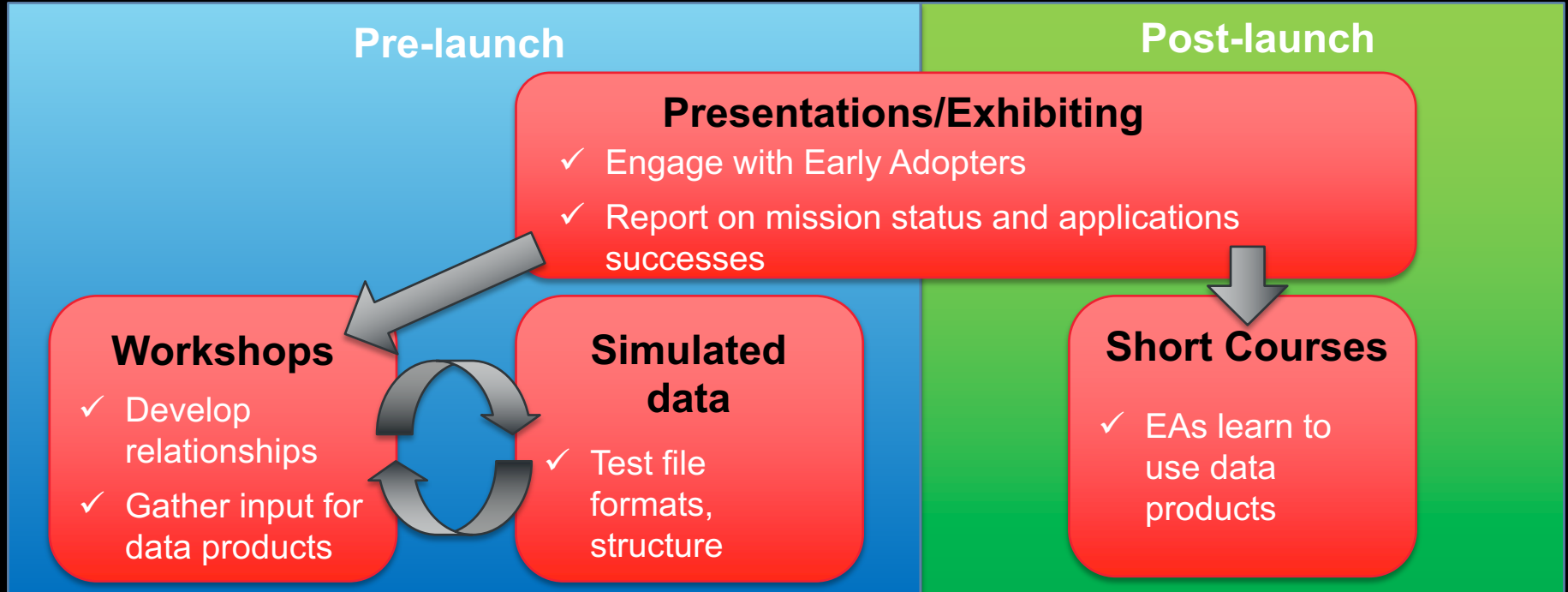
- ✓ MAIA has a large community of collaborators/potential users
- ✓ Organizes contacts for quick reference by the MAIA team

Early Adopters Program

- ✓ Expand the user base of MAIA data products
- ✓ Focuses on epidemiologists; others included as opportunity allows

MAIA Early Adopters Program

MAIA's EA program is targeted toward increasing MAIA data product use by epidemiologists



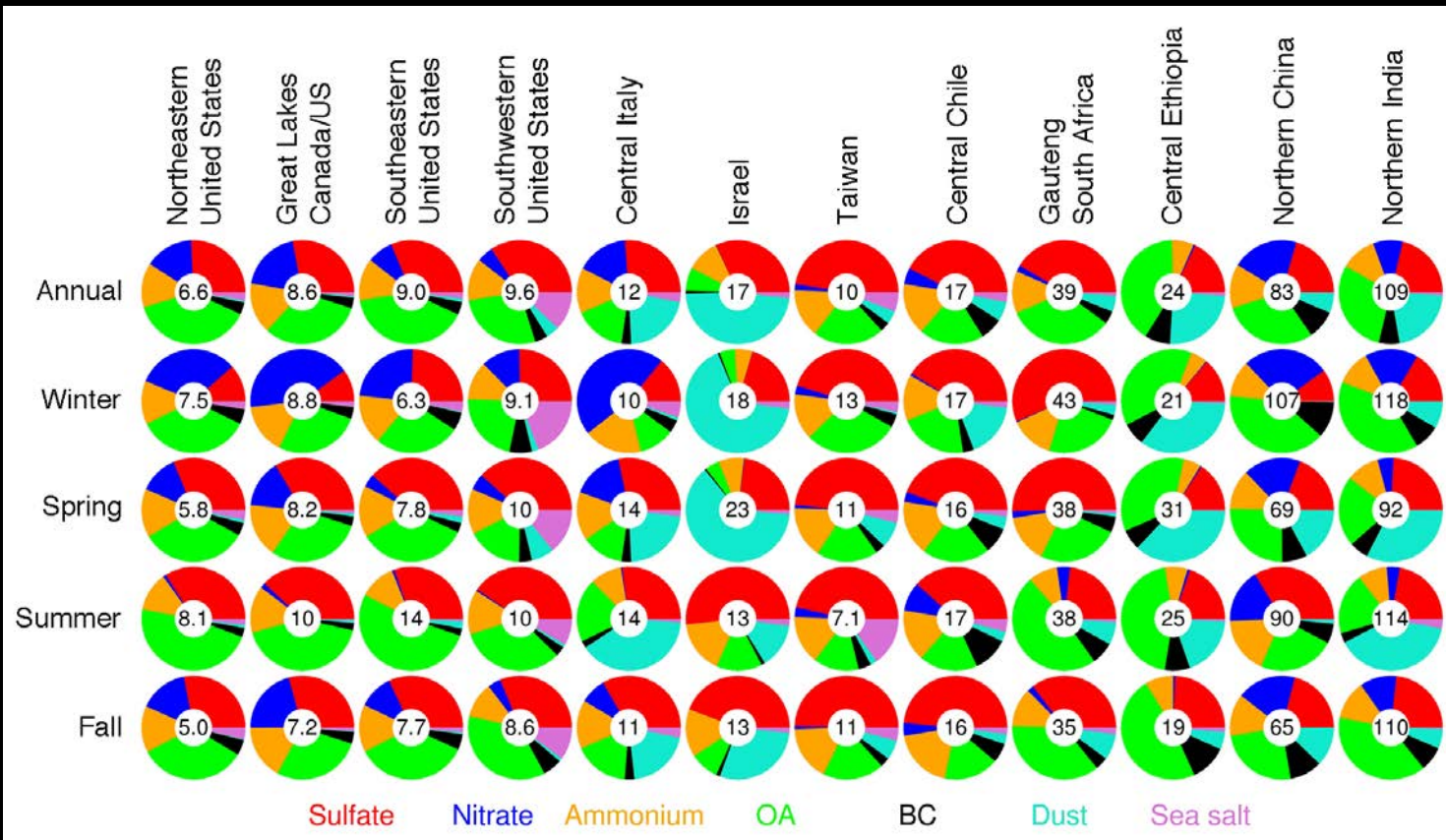
PTA/STA selection



Selection criteria

- Large population for statistical power
- Surface monitor availability/affordability and open data access
- Availability of health records
- Orbit considerations and frequency of observations
- Spatially/temporally contrasting particle types
- Low cloud cover

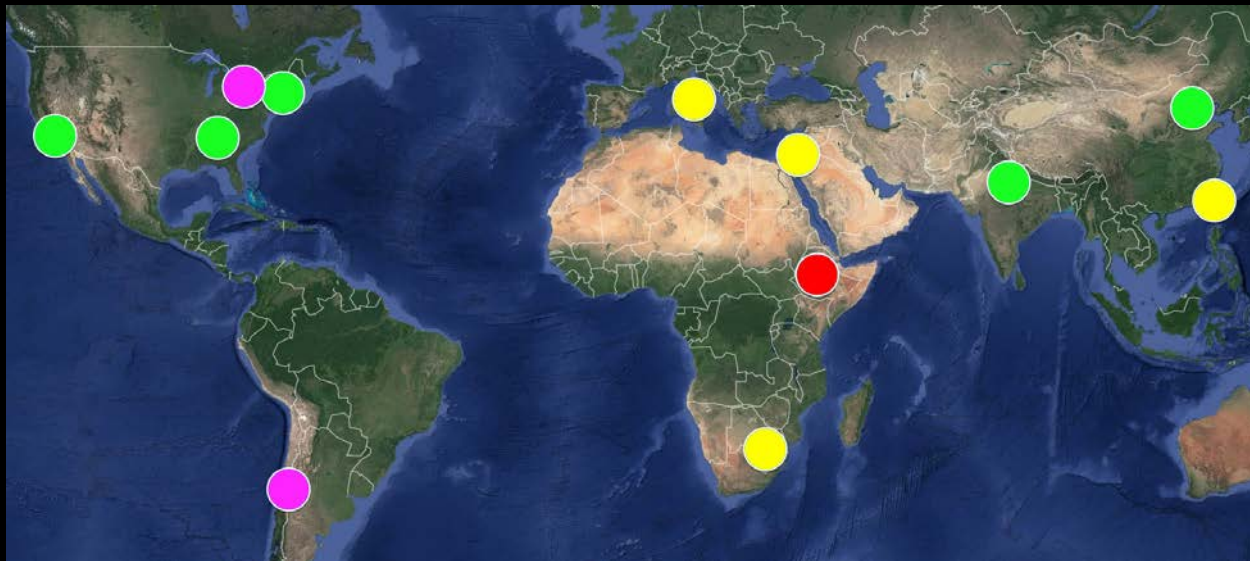
PM amounts and characteristics



Surface monitor requirements

Category	Example requirements	
Monitors per PTA	PM _{2.5} monitors	≥10
	PM ₁₀ monitors	≥3
	Speciated PM _{2.5} monitors	≥2
Data latency	Total PM _{2.5} and PM ₁₀	≤1 month of acquisition
	Speciated PM _{2.5}	≤12 months of acquisition

Surface monitor summary



Meets requirements

Work need to resolve data access/latency

Continuous OR speciation monitors needed

Continuous AND speciation monitors needed

Health Studies

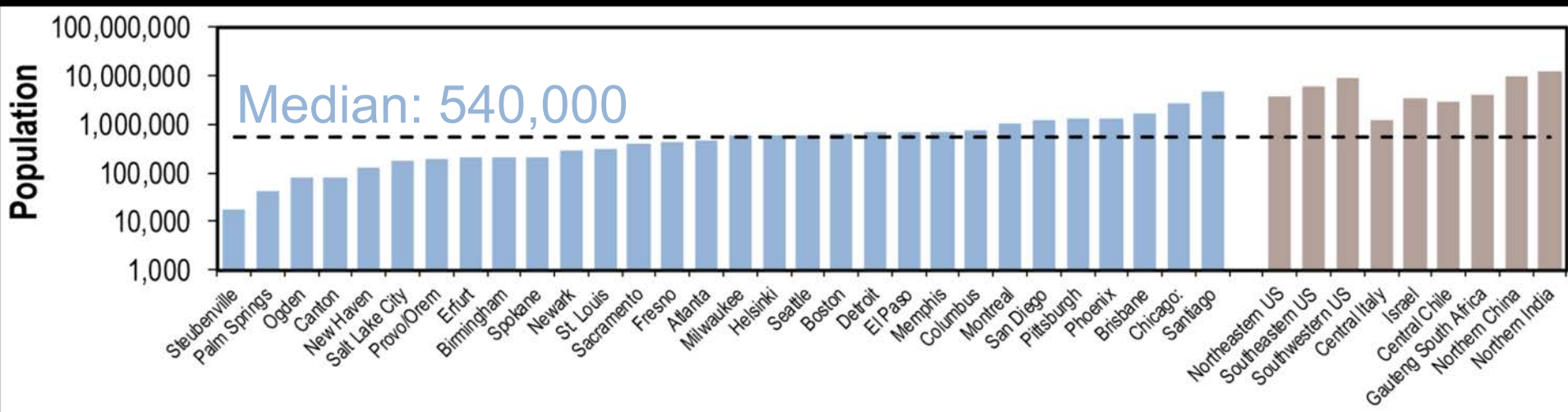
PTA	Representative major cities	Acute	Subchronic	Chronic
NE US	Boston, Providence, Hartford			
Great Lakes Canada/US	Toronto, Hamilton, Pittsburgh			
SE US	Atlanta			
SW US	LA, Fresno, Bakersfield, Riverside			
Central Italy	Rome, Bologna			
Israel	Tel Aviv, Haifa, Jerusalem, Beer Sheba			
Taiwan	Taipei, Taichung, Tainan, Kaohsiung			
Central Chile	Santiago, Rancagua, Talca			
Gauteng South Africa	Johannesburg, Pretoria			
Central Ethiopia	Addis Ababa, Adama (in collaboration with Ebba Malmqvist, Lund University)			
Northern China	Beijing			
Northern India	Delhi			

Acute (days to weeks)
Hospital visits, heart attacks,
strokes, premature deaths

Subchronic (months)
Adverse birth outcomes,
pregnancy complications

Chronic (years)
Cardiovascular and
respiratory diseases, cancer

Population

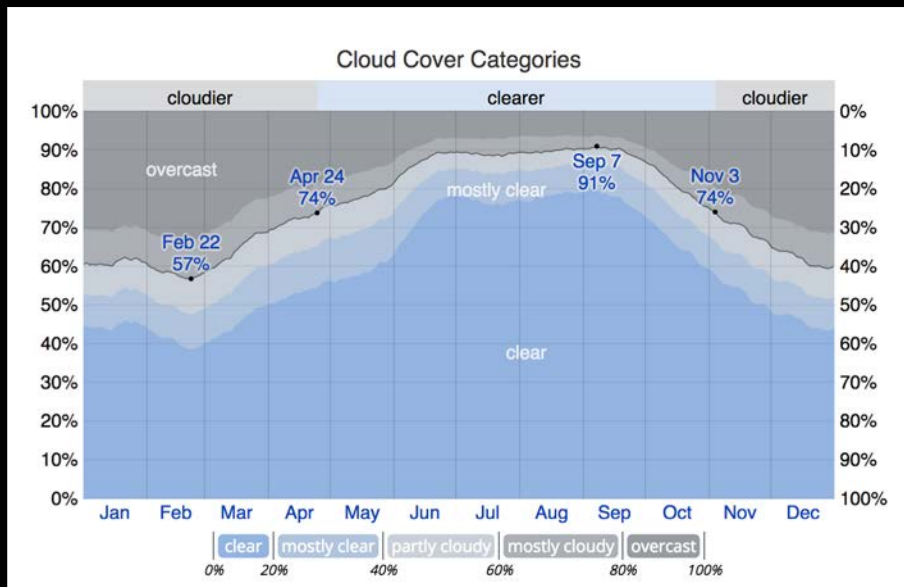


Previous acute exposure study populations PTA candidates

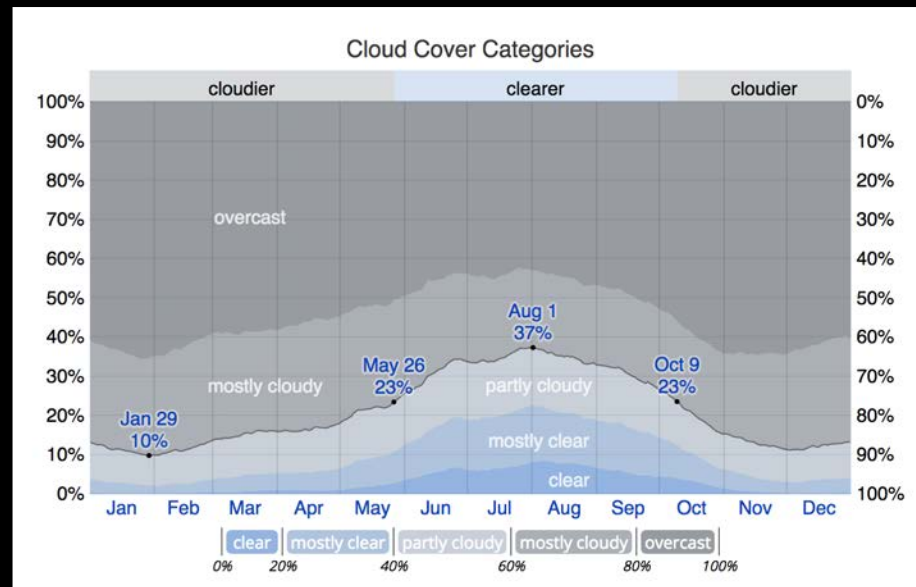
Sub-chronic studies: 11,000 births

Chronic studies: Cohorts > 70,000

Cloudiness



✓ Los Angeles



✗ Jakarta

Source: Weatherspark

VERY preliminary STA candidates



Candidate target areas



PTA



STA



CVTA

- 1 Cloud field
- 2 Arizona (Phoenix)
- 3 Mexico (Mexico City)
- 4 Peru (Lima)
- 5 Brazil (São Paulo)
- 6 Senegal (Dakar)
- 7 Cloud field
- 8 Nigeria (Lagos)
- 9 Spain (Barcelona)
- 10 Kuwait (Kuwait City)
- 11 Bangladesh (Dhaka)
- 12 Vietnam (Hanoi)
- 13 South Korea (Seoul)
- 14 Australia (Sydney)

Example STA selection criteria

Scientific merit: Types/concentrations of PM? Important sources? Concerns of local researchers/agencies? Seasonal variations/periodic events? Opportunities to advance the state of air quality/health research?

Surface monitors: continuous PM monitors, PM2.5 speciation monitors measuring sulfate, nitrate, BC, OC/EC, and dust, and AERONETs.

Reliable contacts: Individuals leading health studies, operating/maintaining local surface monitors, and providing surface monitor data? Potential partnerships with other air quality monitoring efforts?

Any planned air quality or health studies

No conflicts with Primary Target Areas (PTAs)

Next steps...

- Finalize PTA selections
- Begin secondary target selection

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